BRITISH ECONOMIC GROWTH, 1270-1870

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Abstract: We provide annual estimates of GDP for England between 1270 and 1700 and for Great Britain between 1700 and 1870, constructed from the output side. The GDP data are combined with population estimates to calculate GDP per capita. We find English per capita income growth of 0.20 per cent per annum between 1270 and 1700, although growth was episodic, with the strongest growth during the Black Death crisis of the fourteenth century and in the second half of the seventeenth century. For the period 1700-1870, we find British per capita income growth of 0.48 per cent, broadly in line with the widely accepted Crafts/Harley estimates. This modest trend growth in per capita income since 1270 suggests that, working back from the present, living standards in the late medieval period were well above "bare bones subsistence". This can be reconciled with modest levels of kilocalorie consumption per head because of the very large share of pastoral production in agriculture.

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I. INTRODUCTION

Two very contrasting view of the development of the British economy between the late medieval period and the Industrial Revolution co-exist. One view, which has been based largely on real wage evidence, paints a bleak picture of long run stagnation from the late thirteenth century to the middle of the nineteenth century, albeit with quite large fluctuations over sustained periods (Phelps Brown and Hopkins, 1981). This view has recently been supported by Clark (2005), who provides a real wage series which shows less extreme fluctuations than that of Phelps Brown and Hopkins, but leaves the trend unchanged. Furthermore, Clark (2007a) adds new time series for land rents and capital income to arrive at a picture of long run stagnation in GDP per head. This view sits uneasily with a second view, based largely on estimates of wealth and the appearance of new products, which appears to show modest but sustained growth of living standards between the middle ages and the Industrial Revolution (Overton, Whittle, Dean and Haan, 2004; de Vries, 1994).

These two very different views of the long run development of the British economy have been able to co-exist because of the absence of reliable and empirically well grounded estimates of the output and labour productivity of the British economy over much of this period. This paper forms part of a project to reconstruct the national income of Britain and Holland between the late thirteenth century and the late nineteenth century. Here, we present preliminary annual estimates of British GDP constructed from the output side. For the period before 1700, we work only with estimates for England, but

for the period 1700-1870 our estimates are for the territory of Great Britain, including Wales and Scotland as well as England.

For agriculture, we build on the path breaking study of Overton and Campbell (1996), which tracked long run trends in agricultural output and labour productivity, but was restricted to estimates for a small number of benchmark years. To provide annual estimates, we rely heavily on three data sets assembled for the medieval, early modern and modern periods. For the medieval period, we analyse the Medieval Accounts Database assembled by Campbell (2000; 2007), drawing upon the archival labours of a number of other historians, including David Farmer, John Langdon and Jan Titow. The information on arable yields and animal stocking densities is taken largely from manorial accounts, but is supplemented by information on the non-manorial sector from tithes. For the early modern period, we use the probate inventory database assembled by Overton, Whittle, Dean and Hann (2004), which provides indirect estimates of arable yields and animal stocking densities from the valuation of the assets left by farmers. From the early eighteenth century on, we make use of the database on farm accounts assembled by Turner, Beckett and Afton (2001).

For industry and services, for the period after 1700 we build on the pioneering approach of Deane and Cole (1967), as modified by Crafts and Harley (1992). Gross output indicators for the major sectors have been assembled and weighted using value added shares. For the period before 1700, a similar procedure has been used, drawing on as many sources as possible for the output indicators and assembling new sectoral

weights at the key benchmark years of 1377 and 1522, as well as the more familiar 1688 benchmark based ultimately on the work of Gregory King [1696].

For the period between 1270 and 1700, we find English per capita income growth of 0.20 per cent per annum on average. This cumulates to more than a doubling of per capita incomes, although growth was episodic rather than continuous, with the strongest growth occurring during the Black Death crisis of the fourteenth century and in the second half of the seventeenth century. For the period 1700-1870, we find British per capita income growth of 0.48 per cent per annum, broadly in line with the widely accepted Crafts/Harley estimates. This cumulates to a further doubling of per capita incomes, and again growth was episodic, with periods of faster growth occurring 1780-1801 and 1830-1870. This modest trend growth in per capita income since 1270 suggests that, working back from the present, living standards in the late medieval period were well above what Allen (2009: 36-41) calls "bare bones subsistence". This can be reconciled with modest levels of kilocalorie consumption per head because of the very large share of pastoral production in agriculture. This meant that a large share of the English population were already in a position during the late Middle Ages to afford what Allen calls the "respectable lifestyle", with a more varied diet including meat, dairy produce and ale, as well as the less highly processed grain products that comprised the bulk of the bare bones subsistence diet.

Our estimates of GDP are built up primarily from the output side. However, the national accounting perspective suggests a number of tests which can be conducted to

demonstrate consistency, drawing on estimates from the income and expenditure sides. In particular, we check consistency with the real wage estimates which have been used frequently by economic historians to draw conclusions about long run living standards (Clark, 2005; Allen, 2001). Second, we also consider per capita consumption of kilocalories, to check the sustainability of the population (Overton and Campbell, 1996).

The paper proceeds as follows. Sections II to IV describe the procedures for estimating output in agriculture, industry and services, respectively. Section V then aggregates the sectoral outputs into real GDP for England during the period 1270-1700 and Great Britain during 1700-1870, and combines these series with data on population to derive estimates of GDP per capita. In section VI, we compare the long run evolution of per capita GDP derived from the output side with real wages and examine the per capita consumption of kilocalories in the light of Allen's (2009) distinction between bare bones subsistence and respectable lifestyle baskets. Section VII places British economic growth in a wider international perspective, while section VIII concludes.

II. AGRICULTURAL PRODUCTION

1. Arable farming in England, 1270-1870

The starting point for any estimate of the output of the arable sector is the total area under crop, which is set out in Table 1. For most benchmark years, the data differ slightly from Overton and Campbell (1996), as a result of the incorporation of subsequent scholarship. Firm estimates of land use only became available in the agricultural returns of 1871, which therefore provides the starting point for the series. For 1830, the figures come from

the tithe files and for 1800, 1750 and 1700 from estimates by contemporaries (Holderness, 1989). Here, we have accepted the higher figures suggested by Prince's (1989: 41) interpretation of the 1801 Crop Returns, while the estimates for 1600 have been inferred by extrapolating backwards from these later figures. For the medieval period, the starting point is the estimate for 1300. Around this time, the population attained its medieval peak, so that the arable acreage would also have been at its peak. Contrary to the claims of Clark (2007b: 124), it is unlikely that the arable acreage in 1300 could have been much above the level of 1800. Estimates for other years between 1270 and 1500 are obtained by extrapolation from 1300 on the basis of trends in the cropped acreage on demesnes and tithe data in the non-demesne sector (Campbell *et al*., 1996; Dodds, 2004; Medieval Accounts Database).

Having obtained estimates of the overall arable acreage in use, the next step is to allocate it between fallow and the major crops sown. This information is taken from the Medieval Accounts Database for the period before 1500, the Early Modern Probate Inventories Database for the period 1500-1750 and from Holderness (1989) and Overton (1996) for the period 1750-1850. For the medieval period, it should be noted that we assume the distribution of crops in the demesne sector to be representative of the country as a whole. This is broadly consistent with the much smaller amount of evidence on the non-demesne sector (Sapoznik, 2008; Dodds, 2007). For the period between 1492 and 1553, there is a gap in information as the manorial records come to an end before the probate inventories become available.

The amount of fallow declined from between a third and a half in the medieval period to less than a quarter in the early modern period and to just 3.5 per cent by 1871. Information on the crop distribution is taken from data that are intrinsically local and of uneven geographical coverage, so that a system of regional weightings is essential to ensure a reliable national total. Each region's share of the national sown acreage is taken from the 1801 crop returns, but within each region, the breakdown of crops varies over time in line with the information in the databases. Amongst the principal winter-sown crops, wheat remained important throughout the period, but rye and maslin (a mixture of wheat and rye) declined sharply during the modern period. Amongst the spring-sown crops, barley and dredge (a mixture of barley and oats) remained important throughout the period, but oats declined in relative importance. The biggest increase in the use of arable land was in potatoes and other crops, particularly clover and root crops after 1700 (Overton, 1996: 99-101, 110).

To calculate output from the estimated areas sown with each crop requires information on grain yields per acre, net of seed sown. Weighted national average yields per acre, gross of tithe and seed can be obtained from the manorial accounts for the medieval period, the probate inventories for the early modern period and the farm accounts for the modern period. Each dataset has been divided into seven regional groupings and separate chronologies have been constructed for each region before being combined into a single weighted master chronology for the country as a whole. Due to the discontinuous nature of much of the data, the chronologies are derived using regression analysis with dummy variables for each farm and for each year, as suggested

by Clark (2004). Since our evidence is drawn from the seigniorial sector, we need to consider what was happening in the non-demesne sector. Although Postan (1966) clearly believed that yields were higher on the demesnes as a result of access to better land and more capital, Stone (2006: 21) has recently argued that yields were around 11 per cent higher in the non-demesne sector, where incentives were stronger for peasants. Since the direction of the adjustment is unclear, and would anyway be quite small, we have assumed that yields on the demesne sector were representative of English agriculture as a whole.

Wheat yields gross of seed as well as tithe are shown in Figure 1 for wheat, for illustrative purposes. From these gross yields it is necessary to subtract grain used as seed to derive the net yields shown in Table 2 for all the major crops. There are some differences between crops, but the different datasets appear to tell a consistent story, with yields declining during the late medieval period from around 1300, picking up again during the early modern period from the mid-sixteenth century, and growing more rapidly during the modern period from the early eighteenth century. The data exhibit a high degree of short run volatility, which has been smoothed out in Figure 1 with a 10-year moving average.

In addition to making allowance for grain used as seed, calculation of the net output of the arable sector must take account of consumption of oats and pulses by animals working on the farm. For the medieval and early modern periods, estimates of the numbers of working animals per 100 sown acres can be obtained from the medieval

accounts and probate inventory databases. For the early modern period, these stocking densities are assumed to apply to the whole agricultural sector and hence are simply multiplied with the sown acreage to produce estimates of the numbers of working animals. However, for the medieval period, the demesne stocking densities have been converted into the numbers of horses and oxen on all lands using Wrigley's (2006: 449) assumption that the stocking density of animals on non-seigniorial holdings was three-quarters that on the demesnes. In making these estimates, allowance has been made for both the declining share of demesne acreage and the lesser quantities of fodder consumed by immature animals. As with the crop yields, a regional weighting scheme is needed to derive the stocking densities for the country as a whole from the observations on individual demesnes and farms. For the modern period, direct estimates of animal numbers are taken from Mitchell (1988), Turner (1998) and Allen (2005), since data on stocking densities are unavailable.

Figure 2 sets out the numbers of mature working animals in England. There was a gradual process of substitution of horses for oxen as working animals, beginning in the medieval period. By the nineteenth century, the use of oxen had more or less died out. Using assumptions about consumption of oats and pulses by mature and immature animals, it is possible to derive estimates of farm animal consumption, which are then subtracted from gross output to derive arable output net of seed and animal consumption in Table 3.

During the medieval period, output of wheat and rye, the principal bread grains, declined substantially from the late thirteenth century peak, with a sharp fall in line with population following the Black Death of the mid-fourteenth century. The output decline was even sharper for oats, which fell out of favour as a crop for human consumption. In place of malted oats, malted dredge (a barley/oats mixture) and malted barley became the preferred brewing grains, and demand for barley remained relatively buoyant. Output of pulses also declined relatively slowly during the medieval period.

By the end of the sixteenth century, output of the major grains was back to the peak pre-Black Death level. Output of wheat continued to increase after 1600, while rye declined. This reflected the growing preference for the more expensive bread grain. The output of barley increased markedly in line with the demand for better quality ale brewed from the best barley malt. Output of pulses also grew rapidly during the early modern period, while potatoes became an important crop during the eighteenth century. Output of oats, net of consumption by farm horses, fluctuated more erratically.

2. Pastoral farming in England, 1270-1870

The starting point for deriving the numbers of non-working animals is again the stocking densities. As with the working animals, particular care must be taken for the medieval period in moving from the stocking densities on the demesnes to the numbers of animals in the country as a whole. Conversion of the seigniorial stocking densities into corresponding national densities and numbers of animals is based on four key assumptions. First, following Allen (2005), it has been assumed that due to their high unit

capital value, the density of cattle was one-third lower on the non-demesne lands. However, we have also made an allowance for the negative relationship between farm size and stocking density, drawn from the post-1550 data. Second, again following Allen (2005), mature cattle have been divided into milk and beef animals in the ratio 53 to 47 percent. Third, swine, a popular animal with peasants, are assumed to have been stocked by non-seigniorial producers at the same density as on the demesnes.[1] Fourth, aggregate sheep numbers are assumed to have been stationary in the long term, in contrast to their dynamic growth in the seigniorial sector. This is consistent with trends in exports, inferred levels of domestic demand, and the decline in average fleece weights noted by Stephenson (1988: 380).

Stocking densities can also be obtained for the early modern period from probate inventories, but are unavailable for the modern period. For 1750 onwards, animal numbers are taken directly from contemporary estimates from John (1989), Mitchell (1988) and Turner (1998), and interpolated using data on annual sales at Smithfield and the Metropolitan Cattle Market from Mitchell (1988: 708) and Perren (1975: 388). Non-working animal numbers for the whole period 1270-1870 are shown in Figure 3, taking 10-year moving averages to smooth out short run volatility.

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[1] Note that if we were to adopt Wrigley's (2006) assumption that swine were stocked at twice the manorial density by peasants, this would produce an implausibly large jump in swine numbers between the late medieval and early modern periods.

Calculating the output of the pastoral sector is more speculative than the equivalent calculation for the arable sector, since the percentages of animals producing specific products and the yields per animal have attracted less attention from historians than crop yields. Until more systematic work is done on the sources, the estimates advanced here are necessarily provisional.

Table 4 sets out the numbers of non-working animals, with cattle divided between milk and beef herds and calves. The proportions of animals assumed to have been producing milk, meat and wool are set out in Table 5. A high proportion of cows are assumed to have produced milk and a high proportion of sheep to have yielded wool. Meat, however, was produced only by those animals that were slaughtered. Following Holderness (1989: 147), it is assumed that approximately a quarter of the stock of cattle and sheep and around half of all pigs were slaughtered in the early modern period. These ratios are also applied to the late medieval period for sheep and pigs, in line with slaughter rates documented by Campbell (1995: 164-167). For cattle, however, slaughter rates were lower in the medieval period because there were few herds kept specifically for beef. By 1850, however, cattle herds were increasingly being kept for the production of beef, so that slaughter rates increased. Similarly, for sheep there was a shift from wool to mutton production in the modern period, simultaneously raising the percentage of animals producing mutton and reducing the percentage producing wool. For pigs, high slaughter rates of 100 per cent were possible because of the large number of piglets produced during the year. These basic assumptions have been qualified with additional information from Clark (1991) and Ecclestone (1996).

The next step in the calculations involves the estimation of yields of milk, meat and wool per animal. Table 6 sets out our preferred estimates, drawn from a number of sources, including Clark (1991), Allen (2005), Stephenson (1988) and Britnell (2004). Data between benchmark years were interpolated using information on the relative prices of pastoral products and the animals from which they were derived. Finally, Table 7 combines the information on numbers of animals, percentages of each animal producing and yields per animal to provide estimates of output in the pastoral farming sector.

Further assumptions are needed to derive output estimates for hay, hides and skins, and dairy products. Hay output is derived from the numbers of non-farm horses, on the assumption that each horse consumed 2.4 tons of hay per year (Allen, 2005). Output of hides and skins is derived from the numbers of working and non-working animals using assumptions on the percentages of each animal producing and yields per animal from Clark (1991), Clarkson (1989) and Ecclestone (1996). In the dairy sector, output is split between cheese, butter and fresh milk using data from Biddick (1989) and Holderness (1989).

3. Total agricultural output in England, 1270-1870

Multiplying the output volumes by their prices yields the total value of net output. The price data are taken largely from Clark (2004), who synthesises the published data of Beveridge (1939), Thorold Rogers (1866-1902: volumes 1-30) and the multi-volume *Agrarian History of England and Wales*, as well as integrating new archival material,

principally from the unpublished papers of William Beveridge and David Farmer. To this, have been added the prices of hides from Thorold Rogers (1866-1902) and of rye from Farmer (1988; 1991), as well as direct estimates from the Early Modern Probate Inventories Database. Output can be valued in both current prices and in constant 1700 prices.

Figure 4 plots arable, pastoral and total agricultural output in constant prices on a logarithmic scale, while Table 8 summarises the same information in growth rate form, using 10-year averages to capture long run trends. It should be noted that the gap between 1492 and 1553 in the series for arable and pastoral production has been filled at the level of total agricultural output using the demand function approach of Crafts (1985) and Allen (2000). Agricultural consumption per head is assumed to be a function of its own price (P^A), the general price level (P^Y) and income (Y). Income and price elasticities are estimated from the data for output (adjusted for net imports), prices and real wages over the period 1301-1492 and 1553-1700, and used to predict the missing values of output between 1492 and 1553, based upon the known values of prices and real wages for this period. The results are discussed in detail in Broadberry and van Leeuwen (2010a).

During the medieval period, arable output exhibited a clear downward trend, while pastoral output showed greater stability. Agriculture as a whole thus showed a modest decline in output. From the mid-sixteenth century, arable and pastoral output both grew, with the pastoral sector at first lagging behind the arable sector, but outpacing it from the mid-seventeenth century.

The pastoral sector was thus increasing its share of real agricultural output during the medieval period and from the mid-seventeenth century. However, in current price terms the picture is complicated by changes in relative prices. In particular, although the price of pastoral products relative to arable products was fairly stable during the medieval period, it then trended downwards, particularly during the "Great Inflation" of the sixteenth century. This amplified the effects of the slower real growth of the pastoral sector between the 1450s and the 1650s, and then dampened the effects of the faster pastoral growth after 1650. Thus the current price data in Table 9 show the pastoral sector increasing its share of output during the medieval period and again from the mid-seventeenth century. Between the mid-fifteenth century and the mid-seventeenth century, by contrast, the share of the pastoral sector in current price agricultural output declined.

However, what is perhaps most striking about Table 9 is the already very high share of the pastoral sector in medieval England. This meant that although the English people did not have a particularly generous diet if viewed in terms of kilocalories, it was a varied diet, with meat, dairy produce and ale to supplement the less highly processed grain products that made up the bulk of the diet.

III. INDUSTRIAL PRODUCTION

1. Industrial output in England, 1270-1700

For the period 1270-1700, it is possible to obtain volume measures of some of the key industries, which can be broken down into three major sectors: metals and mining;

textiles and leather; and other industries. The metals and mining sector is based on physical output volumes for a number of important industries. Tin output is available on an annual basis for the whole period from 1301 with relatively few gaps, from Hatcher (1973: 156-159) and Mitchell (1988: 303-304). King (2005) provides data on bar iron production for the period 1490-1700. The output of coal in the 1560s and circa 1700 is taken from Hatcher (1993: 68), interpolated using shipments of coal from north-eastern ports, also taken from Hatcher (1993: 487-495), updating the earlier work of Nef (1932: 380-381).

The textiles and leather sector is based on volume indicators of the key raw material inputs of wool and animal hides. Exports of wool and woollen cloth are given by Carus-Wilson and Coleman (1963) for the period 1280-1554. However, the export of wool is negatively related to the export of cloth, so we use the production of wool from agriculture minus wool exports as an indicator of the woollen textile industry. The output of hides from pastoral agriculture is used to track the output of the leather industry.

Food processing, building and book production are grouped together as the relatively heterogeneous group of other industries. Food processing is assumed to grow in line with agricultural output. Building is assumed to grow in line with population, but with an allowance for urbanisation. For the medieval period, however, allowance has been made for church building, using data on the number of cathedral and abbey building projects derived from Morris (1979: 179). Book production is measured by the index of

new English language book titles obtained from the English Short Title Catalogue (http://estc.bl.uk/F/?func=file&file_name=login-bl-list).

We provide an index of industrial production using the weighting scheme shown in Table 10. The weights for circa 1700 are derived from Hoffmann (1955), but with a number of modifications, including an allowance for the production of books as well as the reworking of the weighting scheme by Crafts et al. (1989). Figure 5 plots the index of industrial production on a logarithmic scale, using a 10-year moving average to remove excessive short run volatility. Table 11 summarises the same information in growth rate form over fifty year periods, using 10-year averages to capture long run trends. Following a period of stagnation in industrial output as population declined after the Black Death, there was a return to industrial growth after 1500, which can be discerned clearly in Figure 5.

2. Industrial output in Great Britain, 1700-1870

Industry is the one sector for which data have previously been analysed at annual frequency during the period 1700-1870, building on the pioneering work of Hoffmann (1955). However, as Crafts (1985) and Harley (1982) pointed out independently, Hoffmann (1955) inadvertently overstated the growth rate of industrial output during the Industrial Revolution as a result of his weighting procedures. The problem is that a few industrial branches, most notably cotton and iron, grew much more rapidly than the rest of industry, and these branches are included in Hoffmann's data set. However, the available time series cover only 56 per cent of industrial output, and the weights of these

industries are increased proportionally to achieve 100 per cent coverage of industrial output. But this means that the unrepresentative, rapidly growing branches of cotton and iron effectively have their weights doubled. Harley (1982) and Crafts *et al.* (1989) propose that only the weights of industries other than cotton and iron should be increased to arrive at 100 per cent coverage.

In addition to changing the weighting scheme, Harley (1982) and Crafts *et al.* (1989) also replaced some of the older series used by Hoffmann (1955), drawing on the latest scholarship. We use these series, together with some later additions, the most important of which are the new series of bar iron output from King (2005), Feinstein's (1988: 446) series of investment in total buildings and works for output of the building industry, and an index of new English language book titles derived from the English Short Title Catalogue and the British Library for the output of the printing industry.

Figure 6 presents our series for industrial output, together with the "revised best guess" series of Crafts and Harley (1992) and Hoffmann's (1955) original index for contrast. The biggest difference is between the Hoffmann index and the other two indices, as a result of the excessive weight given to cotton textiles and iron in the former. Our series shows slightly slower growth than the Crafts-Harley index during the early eighteenth century, largely as a result of the inclusion of new series, particularly King's (2005) data for the iron industry. From the mid-eighteenth century onwards, differences between the two series are relatively minor, and essentially confirm the picture originally presented in Crafts *et al.* (1989). Output growth accelerated from around 1740 to 1840

before tapering off. Again, there is quite a substantial cyclical dimension to industrial output. Table 12 presents the annual growth rates of industrial output over the conventional sub-periods calculated using both the raw annual data and 10-year averages, together with the Crafts-Harley estimates for comparison.

IV. SERVICES

1. Services in England, 1270-1700

The service sector has received much less attention from economic historians than agriculture and industry. Here, we build on the approach used by Deane and Cole (1967) to estimate service sector output in eighteenth century Britain. For England 1270-1700, we break down services into government, commerce, and housing and domestic service. For government, we use a 10-year moving average of real government revenue from O'Brien and Hunt (1999), which is available for the whole period from the European State Finance Database at http://www.le.ac.uk/hi/bon/ESFDB/frameset.html. For commerce, we combine indicators of international trade and transport, domestic trade and transport and finance, while housing and domestic service are assumed to grow in line with population. International trade and transport is measured by data on wool exports, the distances shipped and the growth of the English shipping tonnage, from Carus-Wilson and Coleman (1963), Fisher (1940; 1950) and Davis (1954; 1962), with log-linear interpolation for missing years. Domestic trade and transport is measured by an index of marketed agricultural and industrial output. Changes in the share of output marketed are captured by the cumulative number of new markets established in the period 1300-1490 and the urban share of the population from 1490 to 1700. The data on the growth of the

market are taken from Letters (2005). Financial intermediation is measured by the inverse of the velocity of circulation, derived from Mayhew (2009), building on Cameron's (1967) finding of a declining velocity over the long run. The inverse of velocity is interacted with population as a scaling factor to derive an index of financial sector activity.

The weights for the main service sectors are shown in Table 13, and are derived from the circa 1700 shares in Crafts (1985: 16). The resulting series for total service sector output is plotted in Figure 7, and the growth rates for the whole period and sub-periods are presented in Table 14. Total service sector output trended downwards during the medieval period, before picking up strongly after 1500.

2. Services in Great Britain, 1700-1870

For Great Britain, 1700-1870, we again follow the approach of Deane and Cole (1967), who provided estimates for benchmark years. Here, however, we provide data at an annual frequency. Also, we take account of the downwards revision by Crafts (1985) of Deane and Cole's estimates of service sector growth, particularly for the early nineteenth century. For the eighteenth century Deane and Cole (1967: 76-78) assumed that "commerce" grew at the same rate as industry, that "rent and miscellaneous services" increased in line with population, and that "government and defence" could be measured by real public expenditure. Crafts (1985: 35-37) made only minor changes here. For the nineteenth century, however, Deane and Cole (1967: 166) derived estimates of income in "trade and transport", "domestic and personal", "housing", "government, professional

and other services" and deflated them by the Rousseaux price index. Crafts (1985: 31) showed that this produces an implausibly high rate of growth for commerce, and assumed instead that commerce grew in line with national income, thus introducing an element of iteration into the estimates. Crafts (1985: 35-37) used employment growth for domestic and personal services and new estimates of the housing stock for housing. He also revised the growth rate of government using new data on employment growth.

Our estimates are broadly consistent with those of Crafts (1985), but make a few changes to reflect the need for annual data. The most important difference is in commerce, where we measure the growth of output using volume series covering transport, finance and other commerce. This produces results which are not far out of line with the Deane and Cole (1967) assumption for the eighteenth century, that commerce grew in line with industry. This also avoids the iterative element in the Crafts (1985) assumption that commerce grew in line with national income during 1801-30, and ensures consistency of treatment throughout the whole period.

For government, we use civil government and defence expenditure throughout the whole period, deflated using the Schumpeter-Gilboy and Rousseaux price indices from Mitchell (1988: 719-723). For housing, we use the stock estimates of Feinstein (1988: 389), using a regression relationship between housing stock and population to fill in gaps. Output of domestic and personal services is assumed to rise in line with the urban population, as during the pre-1700 period. This inevitably produces a relatively stable

path for output in domestic and personal services, which is consistent with most assessments of this sector.

Our annual index of service sector output is plotted in Figure 8. The trend pattern is of an increase in the growth rate from around 1780. Table 15 presents the annual growth rates of services output over the conventional sub-periods calculated using both the raw annual data and 10-year averages, together with the Crafts-Harley estimates for comparison. Our estimates are clearly very similar to those of Crafts and Harley (1992).

V. REAL GDP, POPULATION AND GDP PER CAPITA

1. Real GDP and GDP per capita in England, 1270-1700

The next step is to construct an index of real GDP for England over the period 1270-1700 from the above output series for agriculture, industry and services, using an appropriate set of weights. Table 16 sets out the weighting scheme, derived from reconstruction of nominal GDP by sector. Real output trends from the sectoral series described earlier in the paper are transformed into current price trends using sectoral price deflators, with absolute levels of GDP in current prices established using an input-output table for 1841. For the period 1270-1450, we use 1381 weights, a year for which it is also possible to establish sectoral labour force shares from the Poll Tax Returns. For the period 1450-1550, we use 1522 weights, matching labour force shares derived from the Muster Rolls. For 1550-1650, we use 1600 weights. Finally, for 1650-1700, we use circa 1700 weights, matching the labour force estimates derived from the original study by Gregory King [1696]. The resulting series, plotted in Figure 9, can be used to calculate growth rates

over 50-year periods, presented in Table 17. English GDP trended down after the Black Death, before returning to positive growth from the late fifteenth century. Over the whole period 1270-1700, the English economy averaged a growth rate of 0.24 per cent per annum.

Ultimately, we are interested in what happened to GDP per capita, the most widely accepted indicator of material living standards over the long run. Although the population of England has been firmly reconstructed by Wrigley and Schofield (1989) and Wrigley *et al.* (1997) for the period since the compulsory registration of births, marriages and deaths, estimates before 1541 are more speculative. For the period after 1541, the data in Table 18 are based on the estimates of Wrigley *et al.* (1997), interpolated using Wrigley and Schofield (1989). For earlier years, our estimates are based on data for individual parishes, extending forwards in time the approach of Hallam (1988). It should be noted that our peak medieval population estimate of 4.81 million in 1348 is a little higher than the range of 4.0 to 4.5 million suggested by Overton and Campbell (1996), but still well below the figure of at least 6 million suggested by Postan (1966) and Smith (1991). As Overton and Campbell (1996) point out, such a high population estimate has implications for other variables such as land use, crop combinations, yields and kilocalorie extraction rates and the share of the population living in towns, which would be hard to square with other evidence. We shall return to this issue in the section on consumption. Note the impact of the Black Death, which struck in 1348-49, leading to an immediate sharp collapse in the population, followed by a further decline which continued until the mid-fifteenth century.

Combining the population data with the real GDP series produces our estimates of GDP per capita growth in Table 19. The trend is of modest positive per capita income growth between 1270 and1700, at an average annual rate of 0.20 per cent. However, the path of growth was episodic. We find that GDP per capita grew substantially during the Black Death crisis of the fourteenth century, and then remained on a plateau between circa 1450 and 1650 before resuming growth during the second half of the seventeenth century. These trends can also be seen in Figure 10, which plots GDP per capita on a logarithmic scale. Note that although there were some isolated bad years between 1550 and 1650, the trend level of per capita income remained above the level of the pre-Black Death period.

Per capita income growth before the Industrial Revolution thus appears to be confined largely to periods of falling population. This may at first sight appear to confirm the Malthusian interpretation of writers such as Postan (1972) and Clark (2007a). The Malthusian model depends on two key assumptions. First, population responds positively to real incomes, so that if real income falls, fertility declines (the preventive check) and mortality increases (the positive check). Second, there is a negative relationship between the population level and real income, because of diminishing returns to labour, holding land fixed. However, it is helpful to follow Mokyr and Voth (2010) in distinguishing between the strong and weak versions of the Malthusian model. In the strong version, the iron law of wages holds, so that if there is a positive shock to real incomes, they are quickly forced back down to “bare bones” subsistence. In the weaker version, the positive

and preventive checks operate, but not sufficiently strongly to bring the economy back to bare bones subsistence. In the weaker version of the Malthusian model, a society may have a per capita income level sufficient for the majority of the population to afford the respectability basket, as a result, for example, of restrictions on fertility through late marriage.

The evidence for pre-industrial England presented above is clearly not consistent with the strong version of the Malthusian model offered by Postan (1972). First, although population was above the medieval peak by 1700, per capita incomes were around twice as high. The economy was able to support a larger population with a smaller proportion working in agriculture, freeing up others to produce the industrial goods and services demanded in a more urbanised society. Second, although it is not known when it first became the norm, late marriage is known to have been prevalent in early modern England (Wrigley and Schofield, 1989; Wrigley *et al*., 1997). Third, fertility limitation and the high share of the pastoral sector meant that living standards for the majority were "respectable" in 1300, and remained so throughout the period. Nevertheless, it must be emphasised that there was a sizeable minority of people at the bottom of the income distribution who were living at bare bones subsistence. Allen (2009: 50) suggests that this group represented 18.3 per cent of the population in 1688, while the social tables constructed by Campbell (2008: 940) for 1290 suggest that this proportion may have been as high as 26 per cent in the medieval period.

The above interpretation is consistent with the weak Malthusian model. However, there is an important way in which pre-industrial England does not fit the Malthusian interpretation, either strong or weak. This is the important role of the growth of London. Whereas Malthus clearly thought in terms of a negative relationship between population density and real income levels through diminishing returns, there is much evidence to suggest that the growth of London acted as a stimulus to productivity and real income levels (Wrigley, 1985; Allen, 2009). This is more in line with the positive relationship between population density and real income levels hypothesised by Boserup (1965; 1981), through effects on intensity of land use in surrounding rural areas and investment in density-dependent infrastructure in the metropolitan centre, thus creating increasing rather than diminishing returns. Furthermore, Campbell et al. (1993) demonstrate the positive influence of the large London market on the organisation of agricultural production in the surrounding counties already during the medieval period, thus casting doubt on a fundamental assumption of the Malthusian model long before the Industrial Revolution.

2. Real GDP and GDP per capita in Great Britain, 1700-1870

For the period 1700-1870, our estimates of real GDP are for the territory of Great Britain. We have assumed that British agriculture can be represented by developments in England, so that the addition of Wales and Scotland merely raises the level of production, leaving the trend and annual fluctuations unchanged. The time series for industry and services refer to the territory of Great Britain. As for the pre-1700 period, sectoral value added weights in Table 20 are derived from the current price GDP estimates obtained by

reflating the real output series, with the absolute levels established using an input-output table for 1841, derived from Horrell et al. (1994), but adjusted from a United Kingdom to a Great Britain basis. 1700 weights are used for the period 1700-1740, 1759 weights for 1740-1780, 1801 weights for 1780-1820 and 1841 weights for 1820-1870. Details of the derivation of sectoral weights are provided in Broadberry and van Leeuwen (2010b).

Putting the three main sectors together using the weights from Table 20, we arrive at the annual index of British real GDP shown in Figure 11. Our series shows much the same pattern of trend growth acceleration as the Crafts-Harley data. This can be seen clearly in Table 21, which presents the annual growth rates of aggregate output over the conventional sub-periods calculated using both the raw annual data and 10-year averages, together with the Crafts-Harley estimates for comparison. Figure 11 shows clearly that the fastest growth was in industry and the slowest growth in agriculture, with services exhibiting an intermediate growth rate.

To see what happened to per capita incomes, it is necessary to provide estimates of the total population of Great Britain. From 1801 onwards, annual data on the population of England, Wales and Scotland are available from Mitchell (1988: 9). For the period before 1801, the population of England has been reconstructed firmly by Wrigley and Schofield (1989) and Wrigley *et al.* (1997). Since less information is available for Wales and Scotland, we assume that the ratio of the population of Wales to England remained the same for the period 1700-1801. For Scotland, we have population estimates

for 1700 and 1750 (Schofield, 1994: 93). Other years are interpolated using the population of England.

Combining the GDP series with the population data produces our estimates of per capita income in Figure 12. Table 22 presents the same material in growth rate form. The main findings are that per capita income growth accelerated considerably between 1780 and 1801, and then slowed down between 1801 and 1830, before accelerating again after 1830. For the period 1700-1870 as a whole, per capita income grew at an annual rate of 0.48 per cent using the 10-year average data.

VI. CROSS-CHECKING THE OUTPUT ESTIMATES

1. Consumption and output

One way of assessing the credibility of the output estimates is to see what they imply about the level and sufficiency of consumption per head. Table 23 assesses the supply of kilocalories available per head of the population. Livi-Bacci (1991) believes that for a population to have been adequately fed required an average food intake of 2,000 kilocalories *per capita* per day, although for a largely agrarian economy such as medieval England, it is reasonable to assume that some of the kilocalories requirements could have been met from home-raised vegetables and poultry, together with wild nuts, berries, fish and game. We should thus be looking for the main arable crops and pastoral products of the agricultural sector to produce around 1,500 kilocalories per person per day to meet the subsistence needs of the population.

The estimates suggest that agricultural output was more than sufficient to meet society's needs after the Black Death, but was significantly less so in 1310/19, the decade of the Great Famine. The picture of English society in the half century before the Black Death that emerges from this table is thus one of an economy under pressure. Note also that it is hard to see how a population much above the 4.72 million average over the decade 1300/09 could have been sustained, given the grain yields and the levels of land use underpinning the output estimates. Even allowing for a 10 per cent higher arable production in the non-demesne-sector, as suggested by Stone (2006), would not change the picture dramatically, as can be seen in the final column.

One issue which is apparent from Table 23 and from the very high share of the pastoral sector highlighted in Table 9 is that a lot of land was devoted to producing relatively expensive kilocalories. Thus the medieval English population does not seem particularly well off if living standards are assessed in terms of kilocalories. However, the diet was highly varied, with a large proportion of the population able to consume meat, dairy produce and ale. This is in striking contrast to a strongly Malthusian economy, with real wages driven down to bare bones subsistence, where the bulk of the population would be deriving the majority of their kilocalories from inferior grains with little processing, such as oatmeal (Allen, 2009: 35-37).

2. Income and output based measures

An alternative way to assess the credibility of our output estimates is to compare them with the long-established estimates of real wages. Phelps Brown and Hopkins (1981)

produced long time series of daily real wages for skilled and unskilled building workers, which apparently painted a picture of Malthusian fluctuations but long run stationarity of material living standards over the period 1270-1870. Subsequent refinements by Allen (2001) present a more subtle picture, with the real wage gains following the Black Death being maintained in Britain and Holland, but eaten away by subsequent population growth in the rest of Europe. Clark (2005) continues to show a substantial decline in British real wages from their medieval peak before recovery from the mid-seventeenth century. Figure 13 charts our per capita GDP estimates together with the Allen and Clark real wage series for unskilled building workers. Real GDP per capita moves more closely in line with the Allen real wage series until the mid-eighteenth century, but after 1750 trends in GDP per capita have more in common with the Clark real wage series.

How should we interpret the approximate doubling of per capita income between 1270 and 1700? We have seen in Table 23 that gains in food consumption per capita over this period were relatively modest, at least measured in terms of kilocalories. The gains in material living standards should thus be seen as arriving more through the consumption of industrial goods and services. This shows up in the path of average wealth at death and the growing urbanisation of the British economy. Overton (2006) uses data on probate inventory totals for Cornwall, Hertfordshire, Kent, Lincolnshire and Worcestershire to show that between 1550 and 1750, median wealth increased from £11.31 to £22.35 in constant prices. Furthermore, looking at sub-periods, Overton finds a decrease in per capita wealth between 1550 and 1620, when GDP per capita also had a slightly negative trend. Malanima (2009a) suggests an urbanisation ratio for England rising from 4.0 per

cent in 1300 to 13.2 per cent by 1700 and 43.0 per cent by 1870, using settlements of at least 10,000 as the cut-off.

VII. BRITAIN IN AN INTERNATIONAL PERSPECTIVE

This paper on British GDP over the long run is part of a project to reconstruct the historical national accounts of Britain and Holland. In addition, estimates of GDP per capita are now available for a number of other countries before 1850. Table 24 thus puts the British experience into a wider international perspective, projecting backwards from Maddison's (2003) widely accepted estimates of GDP per capita in 1850, expressed in 1990 international dollars. However, it is necessary to take care to deal with changes in the territory under consideration.

Whereas Maddison works with constant boundaries for the United Kingdom for the whole period, our estimates refer to Great Britain for the period 1700-1870 and England for the period before 1700. Similarly, while Maddison works with constant boundaries for the Netherlands, the estimates of van Leeuwen and van Zanden (2009) refer to the Netherlands for the period 1800-1870 and Holland for the period before 1800. The changing fortunes of Great Britain/England and the Netherlands/Holland are tracked in part A of Table 24, with other countries being brought into the comparison in panel B. In the cases of both England and Holland, per capita incomes in the late Middle Ages were of the order of $1,000, well above Maddison's figure of $400 in 1000. Even on the eve of the Black Death, we find per capita incomes in England and Holland of more than $800. The figure of $400, or a little more than a dollar a day, is usually taken as the

measure of bare bones subsistence, and is observed for many poor countries in the twentieth century. Estimates for other European countries in part B of Table 24 also suggest late medieval living standards well above $400. In some cases, such as Italy, this may be explained by high levels of urbanisation. For Western Europe as a whole, however, it is explained by mixed agriculture with a large pastoral sector.

The large share of pastoral agriculture had a number of important implications for future growth. First, this was a high value added agriculture, even if it did not produce many more kilocalories per head than arable agriculture. Second, this was a highly capital intensive agriculture, with animals making up a large share of the capital stock. Third, this was an agriculture which was highly intensive in the use of non-human energy. Fourth, the large pastoral sector provided enhanced employment opportunities for females, thus underpinning a relatively high age of marriage for women, which reduced fertility rates and encouraged human capital formation (de Moor and van Zanden, 2010; Voigtländer and Voth, 2010).

In these respects, Western Europe already looked very different from Asia long before what Pomeranz (2000) calls the Great Divergence of the industrial revolution period. Broadberry and Gupta (2006) point out that during the early modern period European wages were significantly above Asian wages, if compared at the exchange rate (the silver wage) rather than the amount of grain they could purchase (the grain wage). This was taken to suggest a higher European productivity in traded goods and services, so that although European consumers could enjoy more industrial goods and services, they

did not necessarily enjoy more agricultural goods. Yet even if European and Asian consumption baskets were broadly similar in terms of the kilocalories they contained, it now looks as though Europeans (especially those able to afford the 'respectability basket") consumed more agricultural value-added than many Asians because of the greater direct and indirect contribution made by animals to the contents of that basket. The per capita GDP estimates for India in Table 24B, taken from Broadberry and Gupta (2009) suggests that although Indian living standards were higher at the peak of the Mughal Empire than in the nineteenth century, they were already by this stage substantially lower than in the most developed parts of Western Europe.

VIII. CONCLUSIONS

This paper provides the first annual estimates of GDP for England between 1270 and 1700 and for Great Britain between 1700 and 1870, constructed from the output side. For agriculture, the estimates rest on a detailed reconstruction of arable and pastoral farming, built up from manorial records during the medieval period, probate inventories during the early modern period and farm accounts during the modern period. For industry and services, indices of gross output are assembled for the major sectors and combined with value added weights. The GDP data are then combined with population estimates to calculate GDP per capita.

Our results suggest English per capita income growth of 0.20 per cent per annum between 1270 and 1700, with the strongest growth after the Black Death and in the second half of the seventeenth century. For the period 1700-1870, we find British per

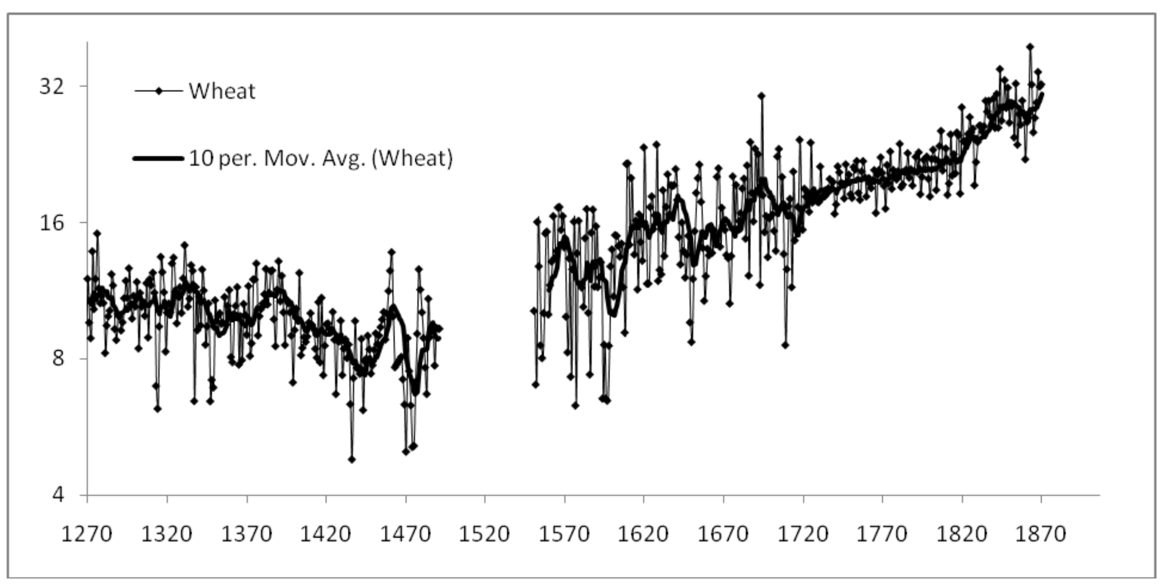
capita income growth of 0.48 per cent per annum, broadly in line with the widely accepted estimates of Crafts and Harley (1992). This modest trend growth in per capita income before the Industrial Revolution suggests that, working back from the present, living standards in the late medieval period were well above "bare bones subsistence". This can be reconciled with modest levels of kilocalorie consumption per head because of the very large share of pastoral production in agriculture. Contrary to the claims of the California School, Western Europe was on a very different path of development from Asia long before the Great Divergence, characterized by high value added, capital intensive and non-human energy intensive production.

TABLE 1: English arable land use (millions of acres)

	Wheat	Rye/ Maslin	Barley/ Dredge	Oats	Pulses	Potatoes	Other crops	Total sown	Fallow arable	Total arable
1270	2.01	0.67	1.13	2.71	0.26	0.00	0.00	6.77	4.75	11.52
1300	2.43	0.55	1.15	2.87	0.40	0.00	0.00	7.40	4.13	11.52
1380	1.66	0.33	1.10	1.69	0.43	0.00	0.00	5.21	3.52	8.73
1420	1.38	0.27	1.03	1.43	0.39	0.00	0.00	4.51	3.25	7.76
1450	1.39	0.28	1.04	1.44	0.40	0.00	0.00	4.55	3.09	7.64
1500	1.45	0.35	1.09	1.43	0.43	0.00	0.10	4.85	2.96	7.81
1600	1.85	0.76	1.44	1.31	0.61	0.00	0.73	6.72	2.16	8.87
1650	2.04	0.40	1.89	1.15	1.03	0.00	1.37	7.87	1.92	9.79
1700	2.02	0.43	1.85	1.17	0.99	0.00	1.31	7.76	1.94	9.70
1750	1.96	0.06	1.51	1.83	0.98	0.09	2.63	9.06	1.62	10.67
1800	2.59	0.06	1.46	2.05	0.83	0.17	3.07	10.23	1.29	11.52
1830	3.33	0.06	1.96	1.56	0.59	0.28	5.09	12.86	1.33	14.19
1871	3.32	0.06	1.96	1.45	0.90	0.39	5.66	13.35	0.48	13.83

Sources: Overton and Campbell (1996: Tables III, V); Campbell et al. (1996); Medieval Accounts Database; Early Modern Probate Inventory Database; Holderness (1989); Overton (1996).

FIGURE 1: English weighted national average wheat yields per acre, gross of tithe and seed (bushels, log scale)



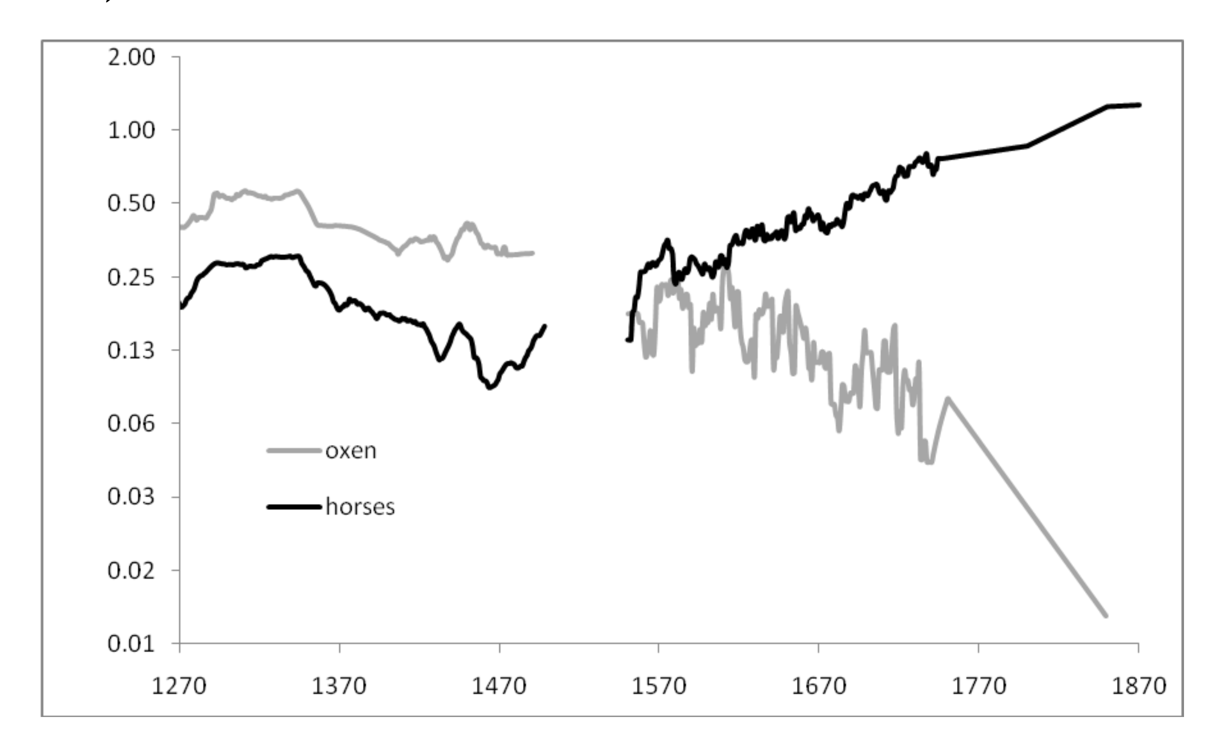
Sources: Medieval Accounts Database, the Early Modern Probate Inventories Database and the Modern Farm Accounts Database.

TABLE 2: English mean yields per acre gross of tithes, net of seeds in bushels (10-year averages)

	Wheat	Rye	Barley	Oats	Pulses	Potatoes
1270-1279	8.54	13.32	10.47	6.61	3.81	
1300-1309	7.99	10.49	9.63	6.08	7.23	
1350-1359	6.91	8.05	7.49	5.35	4.54	
1400-1409	6.75	9.32	8.63	7.06	5.43	
1450-1459	6.52	11.19	7.09	7.01	3.86	
1550-1559	8.98	7.28	8.43	9.80	5.06	
1600-1609	11.43	10.54	12.07	11.62	9.70	
1650-1659	12.93	12.86	16.93	11.14	12.77	
1700-1709	14.38	15.94	17.33	11.54	9.88	150.00
1750-1759	17.75	17.26	20.93	22.66	10.36	150.00
1800-1809	19.43	16.56	23.62	25.28	16.13	150.00
1850-1859	25.25	20.06	26.13	30.60	16.58	150.00
1861-1870	28.19	19.99	27.15	31.69	17.35	150.00

Sources and notes: Gross Yield per acre taken from the Medieval Accounts Database, the Early Modern Probate Inventories Database and the Modern Farm Accounts Database. Seed sown per acre from the Medieval and Modern Databases. Pulses for the modern period and all seeds sown for the early modern period are taken from Overton and Campbell (1996), Allen (2005).

FIGURE 2: Working animals in England in millions (10-year moving averages, log scale)



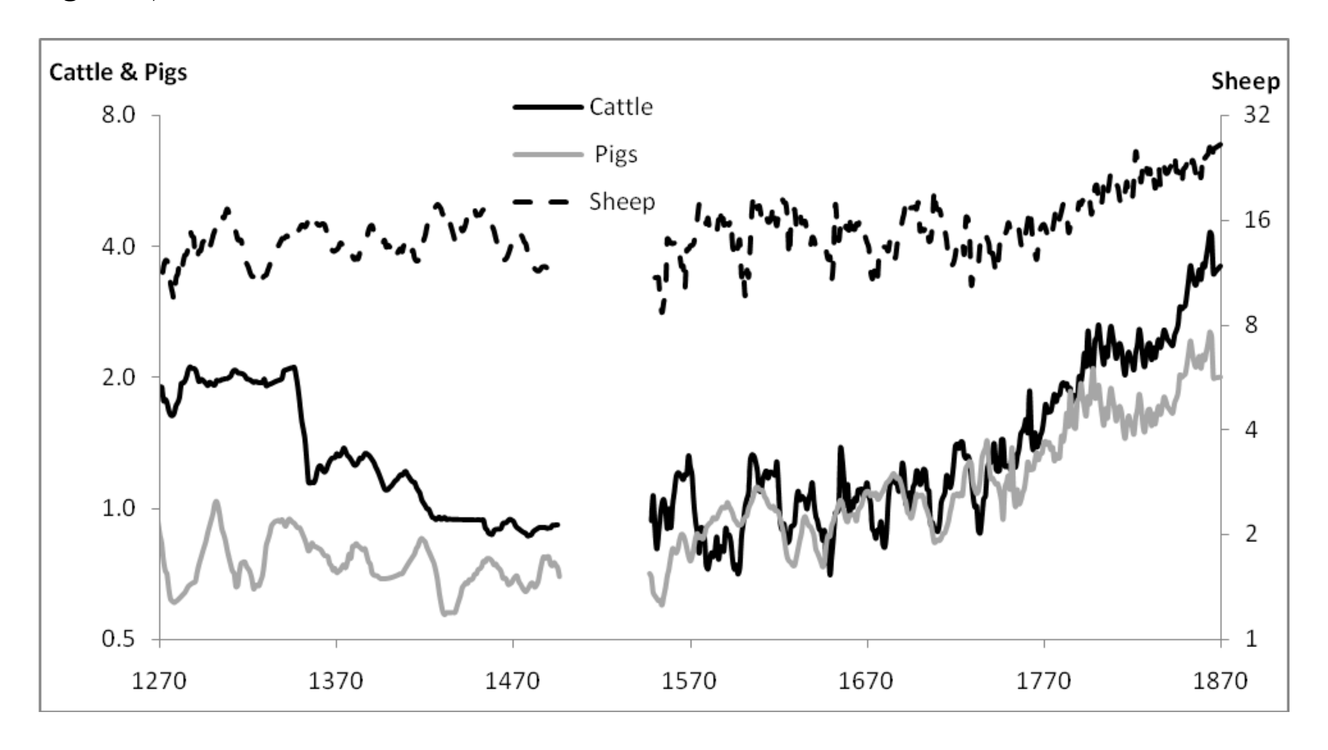
Sources: Derived from the Medieval Accounts Database; the Early Modern Probate Inventories Database; Allen (1994); John (1989); Turner (1998).

TABLE 3: English arable output net of seed and animal consumption in million bushels (10-year averages)

	Wheat	Rye	Barley	Oats	Pulses	Potatoes
1270-1279	17.49	8.81	11.92	15.62	0.51	NA
1300-1309	19.39	5.73	11.06	14.01	1.46	NA
1350-1359	11.91	2.79	8.29	6.34	0.96	NA
1400-1409	9.46	2.59	8.93	7.67	1.08	NA
1450-1459	9.09	3.29	7.40	7.65	0.78	NA
1550-1559	14.75	4.00	10.62	9.14	1.48	NA
1600-1609	21.44	7.53	18.00	9.40	4.00	NA
1650-1659	26.45	4.89	32.32	3.97	9.10	NA
1700-1709	29.75	6.41	30.78	5.21	7.29	1.31
1750-1759	38.63	1.12	30.36	16.36	7.50	13.91
1800-1809	48.54	1.01	34.56	31.16	9.10	25.98
1850-1859	68.36	1.12	68.18	13.97	8.56	47.90
1861-1870	70.75	1.07	83.16	12.91	9.61	50.14

Source: Output gross of tithe and net of seed were derived by multiplying sown area from Table 1 with net yields from Table 2. The sown area from Table 1 was interpolated where necessary. Consumption by working animals was derived from the numbers of working animals shown in Figure 2. For oats, outlying observations based on a very small number of inventories were dropped in 1700-09 and 1750-59, to eliminate excessive volatility.

FIGURE 3: Non-working livestock in England in millions (10-year moving averages, log scale)



Sources: Derived from the Medieval Accounts Database; Early Modern Probate Inventories Database; Allen (2005); John (1989); Mitchell (1988); Turner (1998).

TABLE 4: Numbers of non-working animals in England in millions (10-year averages)

	Milk cattle	Beef cattle	Calves	Sheep	Swine	Livestock units per 100 acres
1270-1279	0.60	0.54	0.60	10.99	0.70	44.07
1300-1309	0.68	0.61	0.68	16.14	0.92	51.37
1350-1359	0.44	0.40	0.44	15.90	0.83	56.15
1400-1409	0.40	0.36	0.40	13.10	0.71	57.45
1450-1459	0.31	0.28	0.31	16.24	0.75	58.16
1550-1559	0.32	0.29	0.32	11.20	0.66	38.04
1600-1609	0.40	0.36	0.40	14.76	1.04	40.99
1650-1659	0.36	0.33	0.36	14.57	0.98	33.84
1700-1709	0.36	0.33	0.36	15.68	0.97	35.04
1750-1759	0.47	0.42	0.47	14.86	1.12	32.44
1800-1809	0.83	0.75	0.83	19.82	1.75	46.18
1850-1859	1.15	1.04	1.15	22.62	2.20	46.49
1861-1870	1.30	1.17	1.30	25.39	2.19	51.46

Sources and notes: Derived from Medieval Accounts Database; Early Modern Probate Inventory Database; Allen (2005); John (1989 Tales III.1 and III.2).
* Livestock units compare different animals on the basis of relative feed requirements. Ratios from Campbell (2000: 104-107): (adult cattle for beef and milk x 1.2) + (immature cattle x 0.8) + (sheep and swine x 0.1).

TABLE 5: Percentages of English animals producing specific products

	Milk	Beef	Veal	Mutton	Pork	Wool
1300	90	15	14.1	26	49	90
1700	90	25	21.1	26	49	90
1850	90	33	25.0	40	100	80

Sources: Holderness (1989: 147); Clark (1991: 216); Ecclestone (1996).

TABLE 6: English yields per animal (10-year averages)

Years	Milk (gallons)	Beef (lb)	Veal (lb)	Mutton (lb)	Pork (lb)	Wool (lb)
1270-1279	100.00	168.00	29.00	22.00	64.00	1.63
1300-1309	100.96	169.26	29.22	22.14	64.11	1.48
1350-1359	112.27	183.91	31.79	23.81	65.36	1.81
1400-1409	124.83	199.82	34.59	25.60	66.64	1.49
1450-1459	138.81	217.11	37.63	27.52	67.94	1.24
1550-1559	172.35	257.50	44.74	31.96	70.62	1.64
1600-1609	200.66	294.44	51.22	36.18	72.00	1.88
1650-1659	233.63	336.68	58.63	40.97	75.85	2.17
1700-1709	272.01	384.98	67.12	46.39	86.56	2.51
1750-1759	316.69	440.22	76.84	52.53	98.78	2.91
1800-1809	368.72	503.37	87.96	59.49	112.72	3.38
1850-1859	429.29	575.59	100.69	67.36	128.63	3.92
1861-1870	443.90	592.82	103.73	69.22	132.42	4.05

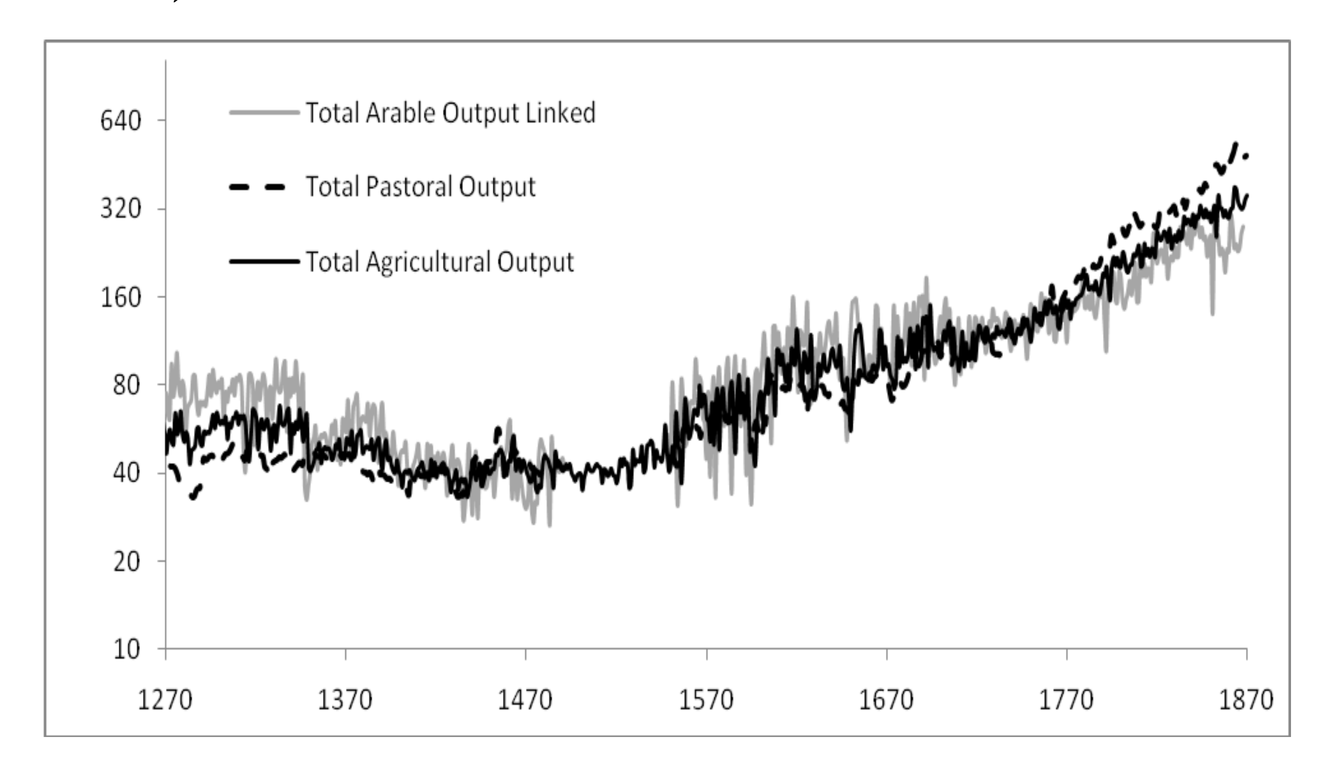
Sources and notes: Beef, pork, milk, and mutton are obtained from Clark (1991: 216), while veal is taken from Allen (2005: Table 6). Wool yield index from Stephenson (1988: Table 3), with the benchmark of 1.4 lb in 1300 from Britnell (2004: 416). The missing years were interpolated in line with the ratio of product to animal prices.

TABLE 7: Output in English pastoral farming (10-year averages)

Years	Milk (m.gals)	Beef (m. lb)	Veal (m. lb)	Mutton (m. lb)	Pork (m. lb)	Wool (m. lb)	Hides (m. lb)	Hay (m. tons)
1270-1279	54.10	13.58	2.54	62.89	21.90	16.13	5.93	0.09
1300-1309	61.72	15.55	2.98	92.94	28.87	21.50	7.72	0.12
1350-1359	44.72	11.74	2.22	98.43	26.63	25.86	7.01	0.10
1400-1409	45.36	12.42	2.32	87.19	23.02	17.57	6.47	0.07
1450-1459	39.06	11.15	2.06	116.19	24.94	18.16	7.41	0.05
1550-1559	50.26	15.61	2.82	93.09	22.72	16.52	7.07	0.09
1600-1609	72.29	23.52	4.19	139.10	36.52	25.03	10.48	0.13
1650-1659	76.56	26.01	4.60	155.30	36.91	28.42	11.91	0.22
1700-1709	89.16	31.91	5.54	191.86	49.67	35.34	14.65	0.32
1750-1759	133.51	51.51	8.59	237.29	78.30	37.32	20.59	0.51
1800-1809	275.67	114.30	18.27	414.29	167.54	55.53	38.03	1.37
1850-1859	443.26	196.73	28.88	609.29	282.94	70.85	53.48	1.93
1861-1870	517.47	228.77	33.59	703.05	290.31	82.19	59.69	1.94

Sources: Total output estimates are derived by multiplying animal numbers from Table 4 with the percentage of animals producing in Table 5. The resulting numbers of producing animals are then multiplied with the animal yields from Table 6.

FIGURE 4: Indexed output in English arable and pastoral agriculture (log scale, 1700=100)



Sources: See text.

TABLE 8: Output growth in English agriculture in constant 1700 prices

Years	Arable sector (% *per annum*)	Pastoral sector (% *per annum*)	Total agriculture (% *per annum*)
1270/79 - 1300/09	0.00	0.99	0.44
1300/09 - 1340/48	0.12	0.04	0.08
1340/48 - 1400/09	-1.00	-0.30	-0.63
1400/09 - 1450/59	-0.13	0.27	0.11
1450/59 - 1470/79	-0.88	-0.45	-0.61
1470/79 - 1553/59	0.66	0.02	0.27
1553/59 - 1600/09	0.93	0.81	0.97
1600/09 - 1650/59	0.52	0.23	0.42
1650/59 - 1700/09	0.15	0.48	0.27
1700/09 - 1750/59	0.15	0.61	0.33
1750/59 - 1800/09	0.45	1.41	0.91
1800/09 – 1830/39	1.18	0.56	0.84
1830/39 - 1861/70	0.22	1.28	0.75
1270/79 - 1340/48	0.06	0.43	0.22
1270/79 - 1700/09	0.12	0.22	0.18
1270/79 - 1861/70	0.21	0.43	0.31
1700/09 - 1861/70	0.45	0.98	0.69

Sources and notes: Derived from Medieval Accounts Database; Early Modern Probate Inventories Database; Modern Farm Accounts Database.

TABLE 9: Output shares in English agriculture, in current prices, 10-year averages (%)

A. Arable products

Year	Wheat	Rye	Barley	Oats	Pulses	Potatoes	Total arable products
1270-79	24.0	5.2	11.2	11.9	0.6		52.9
1350-59	18.8	1.9	8.9	5.8	1.2		36.6
1450-59	15.2	2.3	6.6	4.7	0.9		29.7
1550-59	30.4	4.8	12.6	8.3	1.8		57.9
1650-59	32.4	4.0	20.4	1.8	7.6		66.3
1750-59	32.0	0.6	13.5	8.4	4.0	4.1	62.5
1800-09	28.8	0.4	10.3	6.5	3.4	3.1	52.6
1861-70	17.4	0.2	14.3	1.5	1.9	7.6	42.8

B. Pastoral products

Year	Dairy	Beef	Pork	Mutton	Hay	Wool	Hides	Total pastoral products
1270-79	8.4	2.7	4.3	16.4	0.7	14.0	0.7	47.1
1350-59	8.2	2.5	5.6	30.5	1.2	14.9	0.6	63.4
1450-59	7.6	2.8	6.0	42.3	1.0	9.3	1.3	70.3
1550-59	9.8	2.0	2.8	16.6	1.8	7.2	1.9	42.1
1650-59	7.4	2.2	2.5	12.7	3.0	5.0	1.0	33.7
1750-59	9.4	3.2	4.6	10.9	4.8	3.4	1.2	37.5
1800-09	11.6	5.1	5.6	13.7	7.6	2.9	0.8	47.4
1861-70	16.1	7.1	7.9	14.9	6.2	4.3	0.9	57.2

Sources: Derived from Medieval Accounts Database; Early Modern Probate Inventories Database; Modern Farm Accounts Database.

TABLE 10: English industrial output weights, circa 1700

	%
Tin	1.7
Iron	11.8
Coal	11.4
METALS & MINING	24.9
Woollens	26.6
Leather	14.8
TEXTILES & LEATHER	41.4
Food	21.3
Books	3.6
Building	8.8
OTHER INDUSTRY	33.7
TOTAL INDUSTRY	100.0

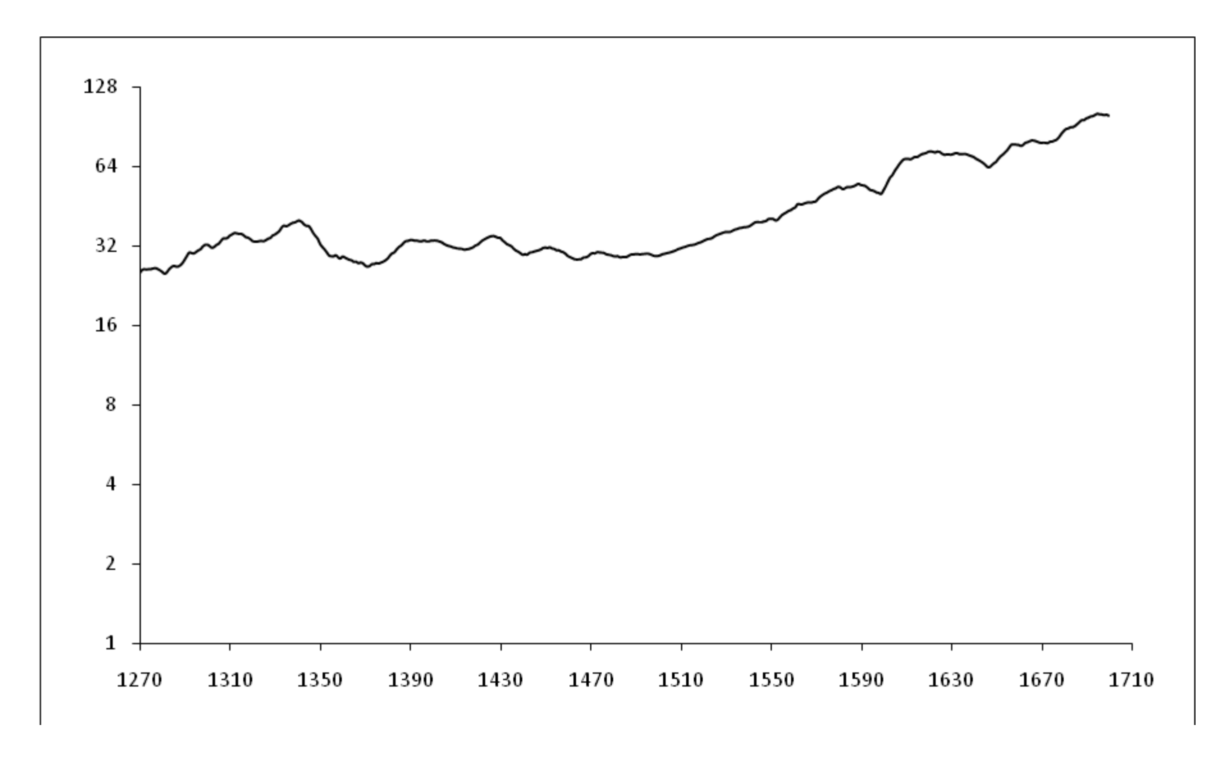
Sources: Derived from Hoffmann (1955) and Crafts et al. (1989).

TABLE 11: Growth of English industrial production, 1270-1700

	% per annum
1270/79 - 1300/09	0.78
1300/09 - 1340/48	0.37
1340/48 - 1400/09	-0.24
1400/09 - 1450/59	-0.11
1450/59 - 1480/89	-0.19
1480/89 - 1553/59	0.50
1553/59 - 1600/09	0.78
1600/09 - 1650/59	0.38
1650/59 - 1691/1700	0.64
1270/79 - 1691/1700	0.32

Sources and notes: See text.

FIGURE 5: English industrial production index, 1270-1700 (10-year moving average, log scale, 1700=100)



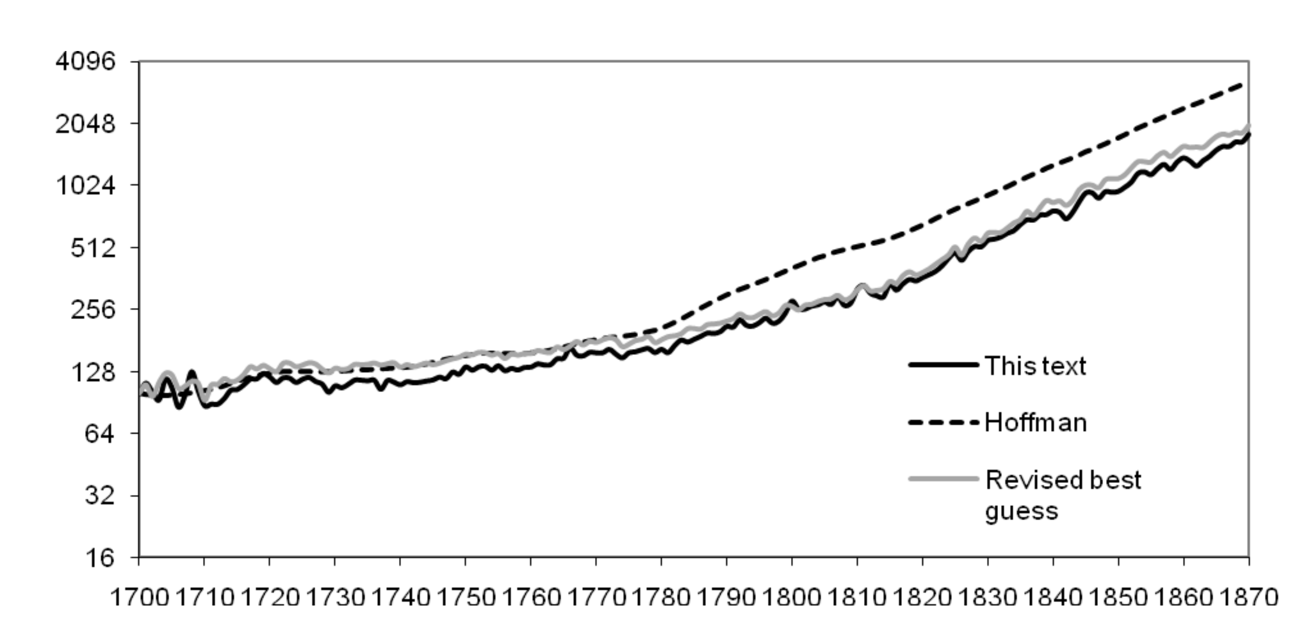
Sources: See text.

TABLE 12: Output growth in British industry, 1700-1870 (% per annum)

	Crafts-Harley	Present estimates (annual data)		Present estimates (10-year averages)
1700-1760	0.71	0.49	1700/09 - 1760/69	0.58
1760-1780	1.29	1.00	1760/69 - 1780/89	1.04
1780-1801	1.96	2.18	1780/89 - 1801/10	2.01
1801-1830	2.78	2.59	1801/10 - 1830/39	2.87
1830-1870		3.01	1830/9 - 1861/70	2.91
1700-1870	--	1.72	1700/09 - 1861/70	1.93

Sources: Crafts (1985: 32); Crafts and Harley (1992: 715); see text.

FIGURE 6: British industrial output in real terms, 1700-1870 (log scale, 1700=100)



Sources: Crafts and Harley (1992); Hoffmann (1955); see text.

TABLE 13: English service sector weights, circa 1700

	%
Commerce	37.2
Of which:	
Finance	5.0
Domestic trade and transport	21.5
International trade and transport	10.7
Housing and domestic	46.6
Government	16.2
Total	100.0

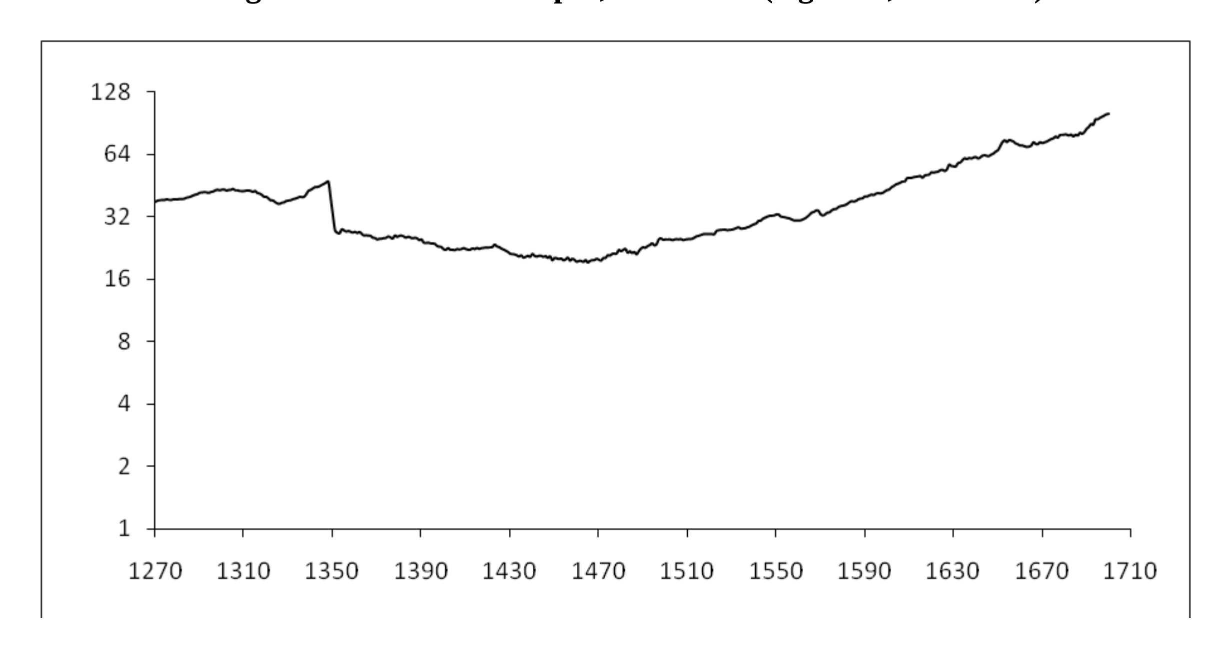
Sources: Derived from Crafts (1985: 16).

TABLE 14: Growth of English service sector output, 1270-1700

	% per annum
1270/79 – 1300/09	0.37
1300/09 - 1340/48	0.13
1340/48 - 1400/09	-1.15
1400/09 - 1450/59	-0.22
1450/59 - 1480/89	0.29
1480/89 - 1553/59	0.49
1553/59 - 1600/09	0.82
1600/09 - 1650/59	0.92
1650/59 - 1691/1700	0.53
1270/79 - 1691/1700	0.21

Sources and notes: See text.

FIGURE 7: English service sector output, 1270-1700 (log scale, 1700=100)



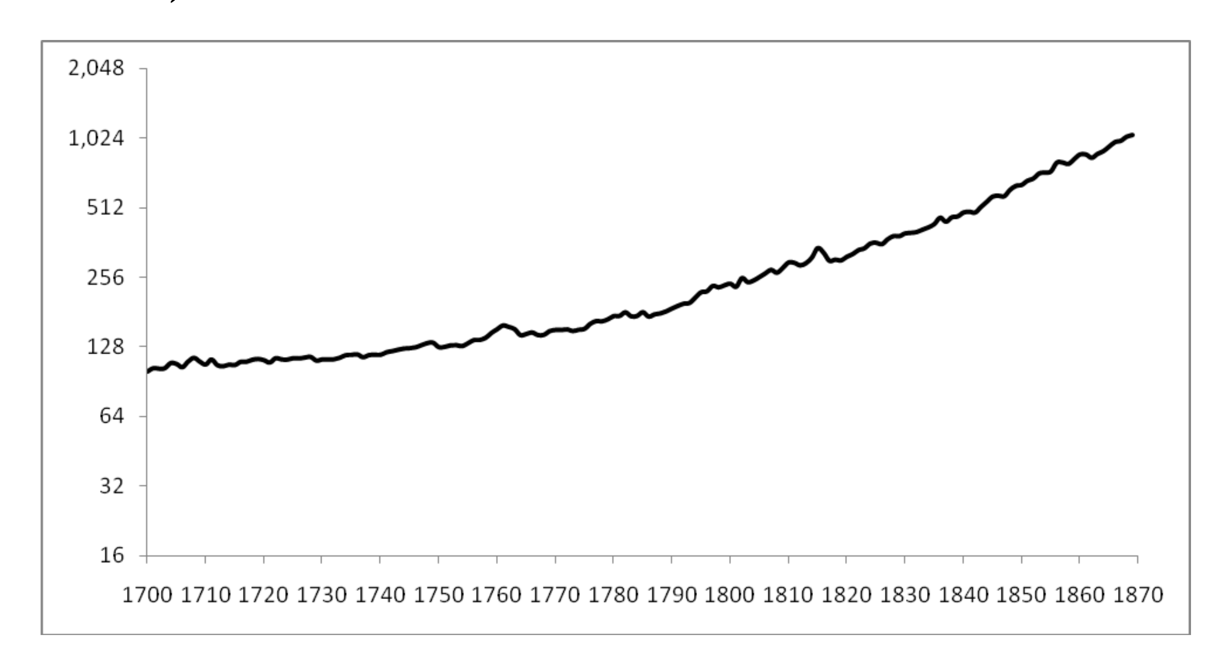
Sources: See text.

TABLE 15: Output growth in British services, 1700-1870 (% per annum)

	Crafts-Harley	Present estimates (annual data)		Present estimates (10-year averages)
1700-1760	0.74	0.71	1700/09 - 1760/69	0.56
1760-1780	0.77	0.66	1760/69 - 1780/89	0.85
1780-1801	1.31	1.40	1780/89 - 1801/10	1.90
1801-1830	1.68	1.79	1801/10 - 1830/39	1.67
1830-1870	--	2.58	1830/39 - 1861/70	2.71
1700-1870	--	1.61	1700/09 - 1861/70	1.58

Sources: Derived from Crafts (1985: 16-17, 32, 37); Crafts and Harley (1992: 715); see text.

FIGURE 8: British service sector output in real terms, 1700-1870 (log scale, 1700=100)



Sources: See text.

TABLE 16: Sectoral shares in English GDP, 1270-1700 (%)

	1381	1522	1600	1700
Agriculture	42.4	35.6	41.8	28.0
Industry	36.3	43.7	34.6	37.8
Services	21.3	20.7	23.6	34.2
Total	100.0	100.0	100.0	100.0

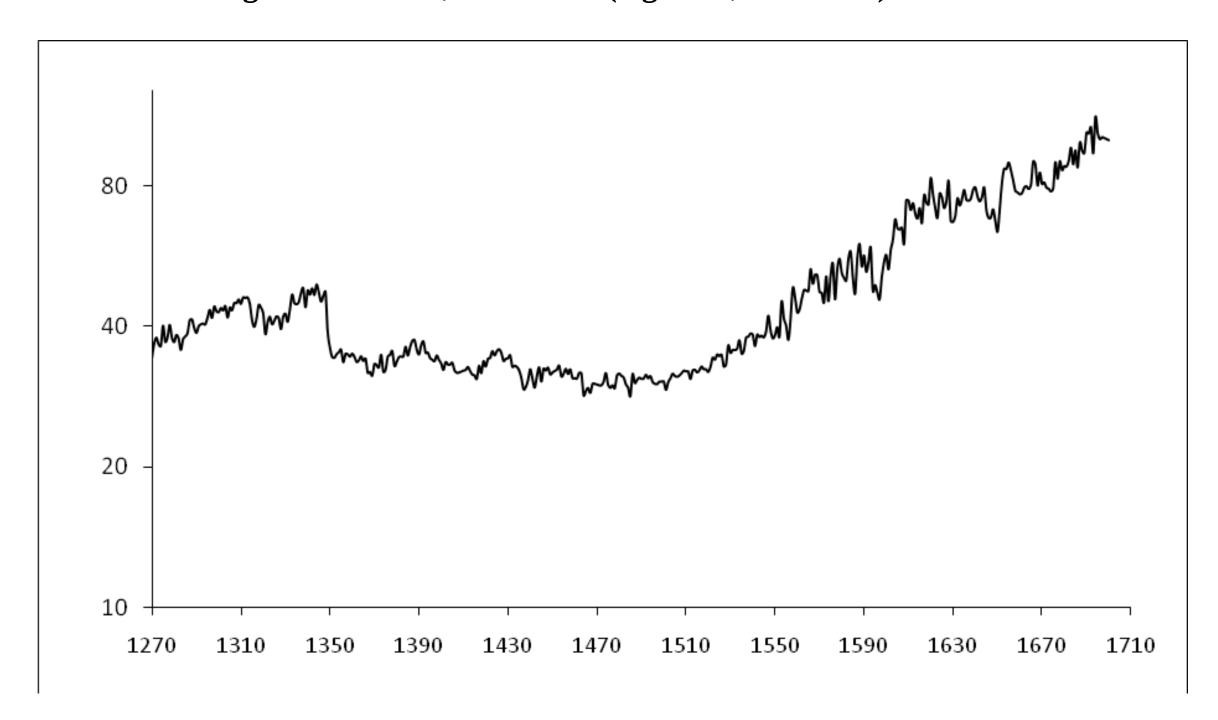
Sources and notes: Derived from reconstruction of nominal GDP by sector. Real output trends above are transformed into current price trends using sectoral price deflators, with absolute levels of GDP in current prices established using an input-output table for 1841; 1381 weights used for 1270-1450; 1522 weights used for 1450-1550; 1600 weights used for 1550-1650; 1700 weights used for 1650-1700.

TABLE 17: Growth of English GDP, 1270-1700

	% per annum
1270/79 – 1300/09	0.52
1300/09 - 1340/48	0.19
1340/48 - 1400/09	-0.60
1400/09 - 1450/59	-0.04
1450/59 - 1480/89	-0.15
1480/89 - 1553/59	0.47
1553/59 - 1600/09	0.79
1600/09 - 1650/59	0.50
1650/59 - 1691/1700	0.48
1270/09 - 1691/1700	0.24

Sources: See text.

FIGURE 9: English real GDP, 1270-1700 (log scale, 1700=100)



Sources: See text.

TABLE 18: English population, 1250-1700

A. Levels of population (millions)

Year	Total population	Year	Total population
1250	4.23	1400	2.08
1290	4.75	1450	1.90
1300	4.73	1490	2.14
1315	4.69	1560	3.02
1348	4.81	1600	4.11
1351	2.60	1650	5.31
1377	2.50	1700	5.20

B. Growth rates of population (% per annum)

	Annual data		10-year averages
1270-1300	0.27	1270/79 – 1300/09	0.23
1300-1348	0.04	1300/09 – 1340/48	-0.02
1348-1400	-1.60	1340/48 - 1400/09	-1.33
1400-1450	-0.18	1400/09 - 1450/59	-0.14
1450-1490	0.29	1450/59 - 1480/89	0.29
1490-1560	0.55	1480/89 - 1553/59	0.54
1560-1600	0.60	1553/59 - 1600/09	0.67
1600-1650	0.51	1600/09 - 1650/59	0.45
1650-1700	-0.04	1650/59 - 1691/1700	-0.08
1270-1700	0.04	1270/79 - 1691/1700	0.04

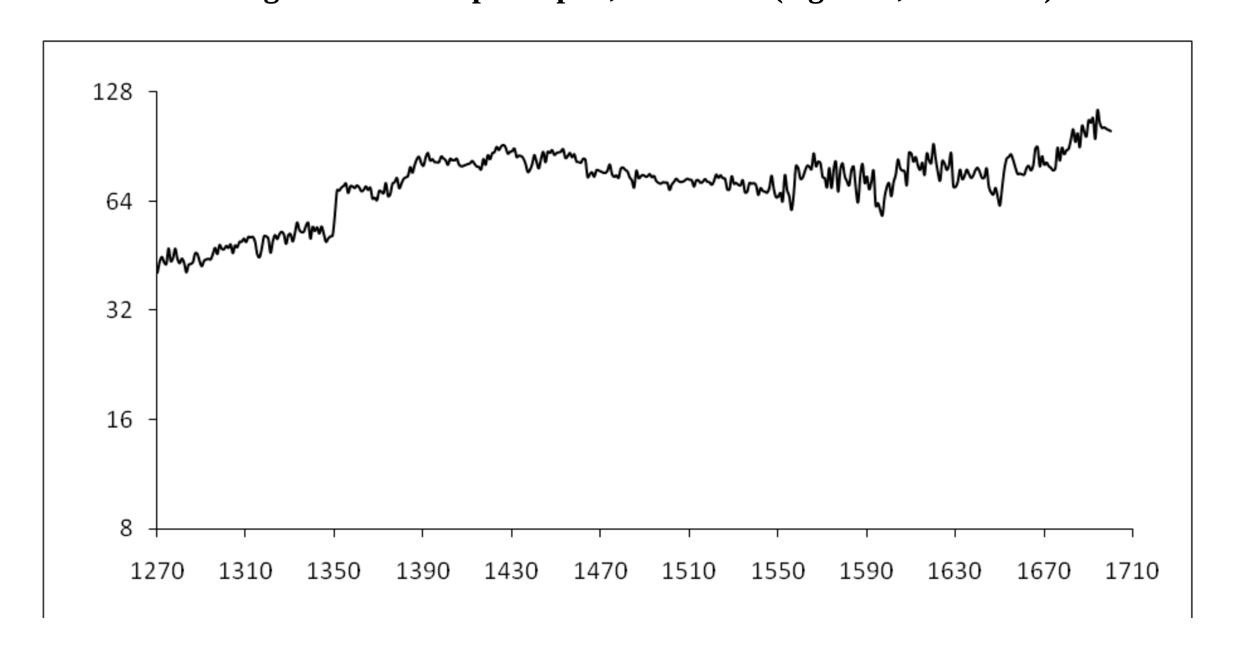
Sources: Medieval period: based on parish data (see text); Wrigley *et al.* (1997), interpolated using Wrigley and Schofield (1989).

TABLE 19: Growth of English GDP per capita, 1270-1700

	% per annum
1270/79 – 1300/09	0.29
1300/09 – 1340/48	0.21
1340/48 - 1400/09	0.73
1400/09 - 1450/59	0.10
1450/59 - 1480/89	-0.44
1480/89 - 1553/59	-0.07
1553/59 - 1600/09	0.12
1600/09 - 1650/59	0.05
1650/59 - 1691/1700	0.57
1270/79 - 1691/1700	0.20

Sources and notes: See text.

FIGURE 10: English real GDP per capita, 1270-1700 (log scale, 1700=100)



Sources: See text.

TABLE 20: British sectoral weights, 1700-1850 (%)

	1700	1759	1801	1841
Agriculture	28.0	26.1	30.9	22.1
Industry	37.8	38.6	31.9	36.4
Services	34.2	35.3	37.2	41.5
GDP	100.0	100.0	100.0	100.0

Sources and notes: Derived from reconstruction of nominal GDP by sector. Real output trends above are transformed into current price trends using sectoral price deflators, with absolute levels of GDP in current prices established using an input-output table for 1841, based on Horrell *et al*. (1994). 1700 weights are used for the period 1700-1740, 1759 weights for 1740-1780, 1801 weights for 1780-1820 and 1841 weights for 1820-1870.

TABLE 21: British GDP growth, 1700-1870 (% per annum)

	Annual data			10-year averages
	Crafts-Harley	Present estimates		Present estimates
1700-1760	0.69	0.63	1700/09 - 1760/69	0.52
1760-1780	0.64	0.81	1760/69 - 1780/89	0.89
1780-1801	1.38	1.54	1780/89 - 1801/10	1.66
1801-1830	1.90	1.69	1801/10 - 1830/39	1.86
1830-1870	--	2.40	1830/39 - 1861/70	2.40
1700-1870	--	1.36	1700/09 - 1861/70	1.31

Sources: Crafts (1985: 45); Crafts and Harley (1992: 715); see text.

FIGURE 11: British GDP in real terms, 1700-1870 (log scale, 1700=100)

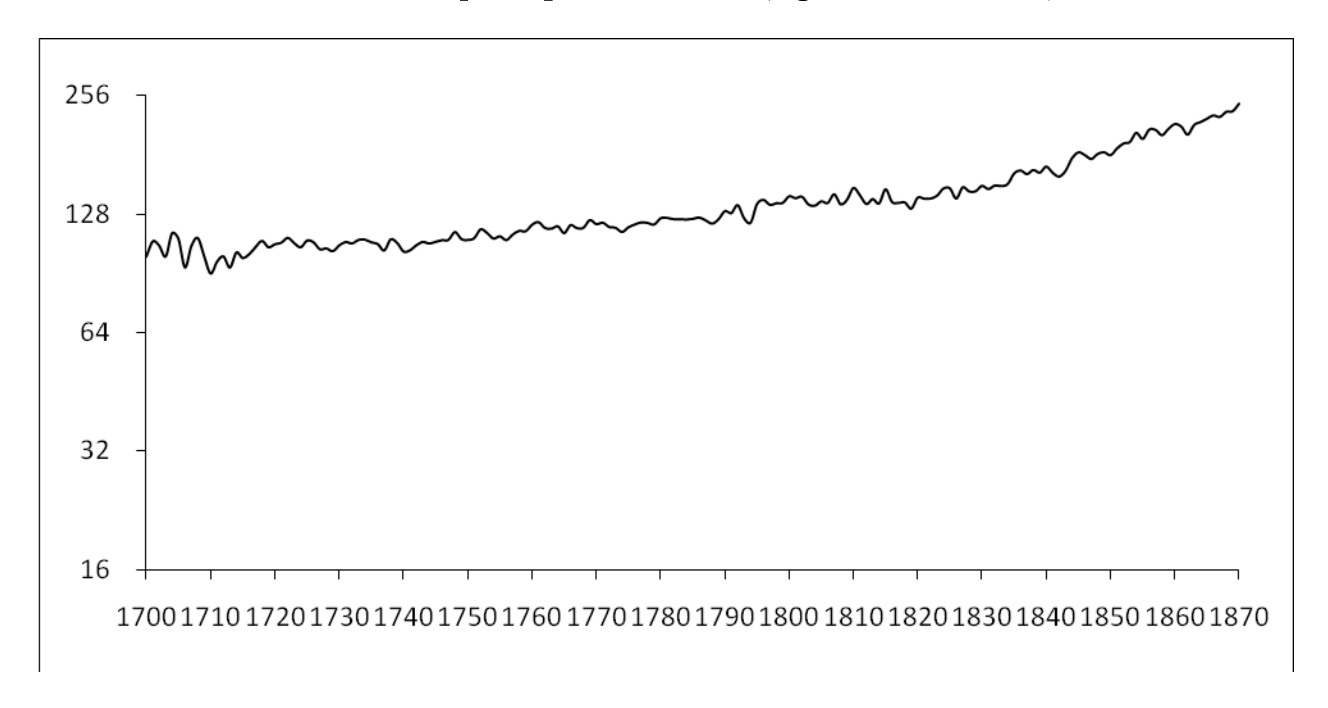
Sources: See text.

TABLE 22: Average annual growth rate of British population and per capita income, 1700-1870 (% per annum)

	Annual data			10-year averages	
	Population growth	Per capita GDP growth		Population growth	Per capita GDP growth
1700-1760	0.32	0.31	1700/09 - 1760/69	0.31	0.21
1760-1780	0.62	0.19	1760/69 - 1780/89	0.68	0.20
1780-1801	0.97	0.56	1780/89 - 1801/10	1.10	0.56
1801-1830	1.43	0.25	1801/10 - 1830/39	1.44	0.42
1830-1870	1.18	1.22	1830/39 - 1861/70	1.21	1.20
1700-1870	0.83	0.53	1700/09 - 1861/70	0.83	0.48

Sources: Mitchell (1988), Wrigley and Schofield (1989), Schofield (1994) and Wrigley *et al.* (1997); see text.

FIGURE 12: British real GDP per capita, 1700-1870 (log scale, 1700 = 100)



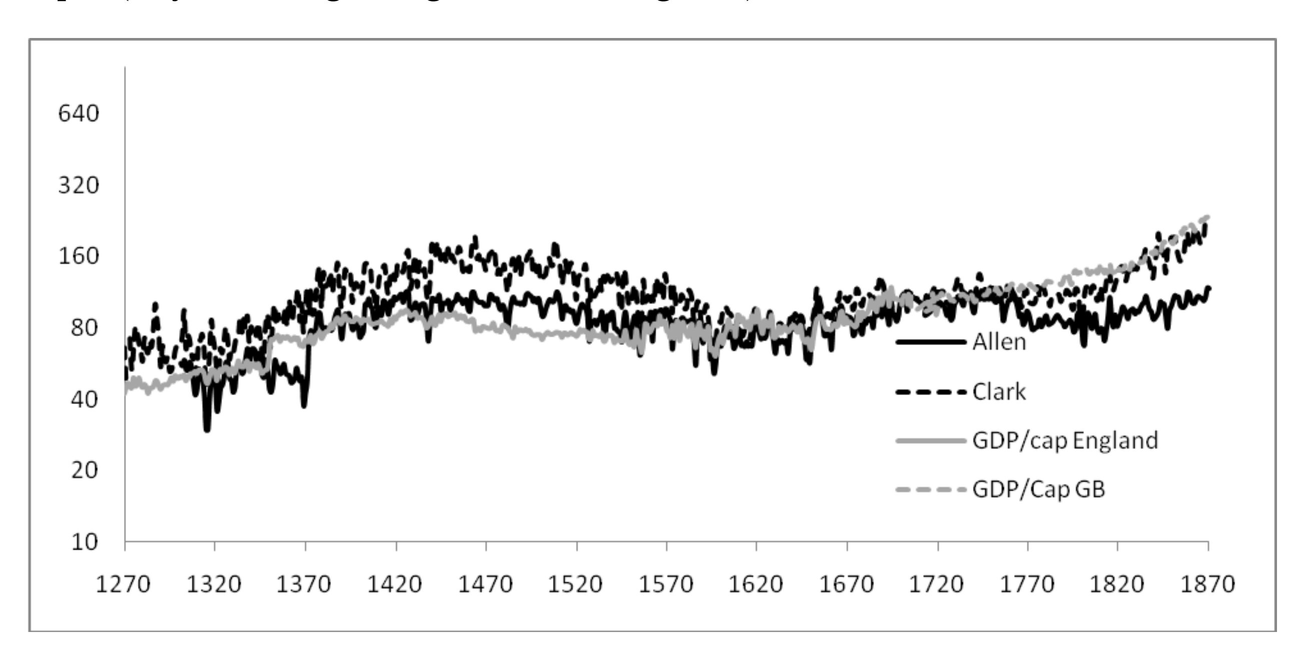
Sources: See text.

TABLE 23: Per capita daily kilocalorie consumption of major arable crops and animal products in England

Years	Population (mlns)	Animal	Arable			Total	Total (10% higher arable production in non-demesne sector)
		Kcal	Kcal. net of seed	Kcal. net of seed, losses, & fodder	% food extraction rate	Kcalories	Kcalories
1270/79	4.40	117	2,671	1,415	*53*	1,531	1,646
1300/09	4.72	139	2,256	1,242	*55*	1,381	1,481
1310/19	4.63	136	2,185	1,199	*55*	1,334	1,432
1380/89	2.36	242	3,603	1,801	*50*	2,042	2,188
1420/29	2.03	292	2,992	1,468	*49*	1,760	1,891
1450/59	1.93	312	3,038	1,512	*50*	1,823	1,958
1600/09	4.27	214	3,140	1,664	*53*	1,877	1,877
1700/09	5.26	242	3,386	1,639	*48*	1,880	1,880
1750/59	6.07	293	3,892	1,878	*48*	2,170	2,170
1800/09	9.06	379	3,422	1,741	*51*	2,120	2,120
1850/59	17.46	329	2,957	1,555	*53*	1,883	1,883

Sources and notes: Kilocalories per bushel for the medieval period are taken from Campbell *et al.* (1993: 41). Following Overton and Campbell (1996: Table XIII), storage losses are assumed to have been 10%, with food conversion losses of 20% for wheat and rye, 22% for barley, and 44% for oats when processed into bread, and 70% for barley and oats when malted and brewed into ale/beer. For the post Black Death period (1380/89 to 1450/59) patterns of grain consumption are assumed to have been equivalent to those for 1600 given by Overton and Campbell (1996: Table XII): 98% of wheat and rye and all oats not fed to livestock were eaten. However, we assumed that 50% of barley was eaten and the remainder brewed. For the pre-Black Death period it is assumed that 60% of barley was eaten and only 40% brewed. For 1600-1850 the estimates of Overton and Campbell (1996: Tables XII and XIII) were followed.
*Includes net grain imports and potatoes.

FIGURE 13: Indexed daily real wage of an unskilled building worker and GDP per capita (10-year moving averages, 1700=100, log scale)



Sources: Allen (2001); Clark (2005); see text.

TABLE 24: GDP per capita levels in 1990 international dollars

A. Northwest Europe

	Great Britain	England	Netherlands	Holland
1270		638		
1300		739		
1348		803		876
1400		1,303		1,195
1500		1,128		1,454
1570		1,172		1,432
1600		1,126		2,662
1650		978		2,691
1700	1,506	1,568		2,105
1750	1,660			2,355
1800	2,140		1,853	2,408
1820	2,124		1,886	
1850	2,718		2,371	
1870	3,670		2,774	

B. Other countries

	Belgium	Italy	Spain	Germany	Sweden	India
1300		1,644				
1400		1,726				
1500	929	1,644	1,295	1,332		
1570	1,089	1,463			860	
1600	1,073	1,302	1,382	894		792
1650	1,203	1,255		1,130		746
1700	1,264	1,398	1,230	1,068		728
1750	1,375	1,553	1,191	1,162		669
1800	1,497	1,333	1,205	1,140	953	646
1820	1,534	1,445			1,009	587
1850	1,841	1,350	1,487	1,428	1,289	594

Sources: Netherlands: van Leuwen and van Zanden (2009); Belgium: Buyst (2009); Blomme and van der Wee (1994); Italy: Malanima (2009b); Spain: Álvarez-Nogal and Prados de la Escosura (2009); Germany: Pfister (2009); Sweden: Krantz (2004); Krantz and Schön (2007); India: Broadberry and Gupta (2009).

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